

ART. VII. *Of the Pulse and its Modifications.* By S. JACKSON, M. D.
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THE pulse has engaged the attention of medical practitioners from the earliest periods of the science, and has deservedly been regarded as furnishing, in the exploration of the human system, the most important symptoms to determine its healthy or pathological condition. The study of the pulse created the sphygmie art; but in the absence of a correct theory of the pulse, that might have restrained the illusions of fancy, a large proportion of what has been written on this subject, is to be set down to exaggerated pretensions, empirical vanity, and fallacious experience.

A theory of the pulse must of necessity be engrafted on, and be modelled after, the theory of the circulation, of which it is a phenomenon. Before the discovery of the circulation, the nature of the pulse was unknown, and ignorance in this respect led to the adoption of many erroneous notions. A great number of pulses were supposed to exist, and every morbid affection to be infallibly indicated by them. At this day, equal extravagances prevail amongst the Chinese, who possess a doctrine of the pulse which is artificial and complicated in proportion to their ignorance of the circulation, and the real nature of the arterial pulsations. The history of the pulse, strikingly illustrates the remark, that without a sound theory, observation and experience most commonly confirm errors, and establish delusions.

The discovery of the circulation, by imparting correct opinions of the character of the pulse, overthrew the system which had been erected on bare hypothesis. Though the idle pretensions that had been claimed for the indicative character of the pulse, were very considerably reduced, still, the immaturity of knowledge in that respect, gave rise to other notions, not less devoid of accuracy. The new principles of indication founded on the pulse, were rather a change of errors than a discovery of the truth.

The present doctrine of the circulation, which makes it to consist of two distinct orders or kinds, executed by different structures, and moved by different forces, produces an entire modification of the doctrine of the pulse, and enables us to give a positive explanation to the various phenomena it manifests, and to estimate their real value as diagnostic and prognostic signs.

The view of the circulation we adopt is its division into, 1st, a vascular or direct; and 2d, a capillary and parenchymatous or inter-

stitial circulation. To the first, belong the heart, arteries, and veins; to the second, the reticulated, interstitial, and parenchymatous texture of the organs. This last is constantly permeated by a certain quantity of fluids, in definite proportions for each species of tissue, which belongs to the tissue as a part of its organization, and hence may be termed *organic fluid* or *humour*. All the phenomena of life are the result of the mutual action of the molecules of this fluid, and the molecules of the solid or organic structure on each other. Constantly undergoing mutations, it requires an incessant renewal, and for the purpose of its renovation is the vascular circulation provided.

The capillary system thus derives its supply of arterialized, or oxygenated, or proper nutritive humour, from the vascular system; it returns back into the vascular system the molecules unfitted for the actions of vitality.

The vascular system is a system solely of supply to the capillaries. Its moving power is the heart. It communicates with the capillaries, placing at their disposition oxygenized or arterial blood, which they attract into themselves in each organ, according to the immediate wants of the organ, and the activity of its actions or excitement. The two orders of vessels, *arteries* and *veins*, composing the vascular system, have a two-fold communication with each other; a direct communication, the artery changing into a vein, and an indirect, through the capillary system.

The force moving the capillary circulation, resides in the capillaries, and belongs to the organized structure. Its nature is not yet satisfactorily developed, but many facts appear to indicate it to be an electro-galvanic power directed by the agency of the nervous system.

Of the vascular circulation, the pulse is an absolute indicator, pointing out its condition in a positive and direct manner. It does not respond as immediately to the various states of the capillary circulation; but as this last exercises a controlling influence over the vascular circulation, aided by induction and a comparison with other symptoms, the pulse indirectly exposes the condition of the capillary and areolar circulation.

The pulse is caused by the shock communicated to the whole mass or column of blood contained in elastic vessels, (*the arteries,*) by the contraction of the ventricles. The vessels opening into the ventricles, and the blood being a continuous mass, in a natural state, completely occupying the cavities of the heart, vessels, capillaries, and parenchyma or areolar texture of the organs—when the ventricles contract, the blood they contain is forced into the arteries, and the sanguine column included in these vessels, receives a simultaneous

impulse in every portion. The pulse is not, consequently, produced, as was long supposed, and is still conjectured to be, by a succession of waves following each other through the vessels. It is every where synchronous, and the diastole of the arteries corresponds with the systole of the heart. SPALLANZANI, in examining the action of the vessels, expressly remarked, in several of his experiments, that the pulsation in the aorta, the mesenteric artery, and its smallest ramifications, was instantaneous. "The aorta," he observes, "when the heart contracted, swelled up at once from its origin to its termination." And although from his notion of the circulation he supposed "the pulsations must occur in succession," yet he acknowledges as the result of his numerous experiments, "that at the very moment the heart contracts, the aorta and the whole of the arterial system seem to beat at one and the same time."

It has been a subject of dispute whether the arteries experienced a dilatation in consequence of the impulse communicated to the blood by the contraction of the ventricles. A very slight dilatation certainly does occur, though much less than was formerly supposed, or might be believed, from observing superficially the pulse. This point appears to be very accurately settled by the experiments of SPALLANZANI, PARRY, and POISEUILLE.

Three circumstances govern the pulse, of which it furnishes the indications: 1st, the frequency or slowness, force and rythm, or order of the ventricular contractions; 2d, the quantum of blood actually contained in the vessels or proper vascular system, which is governed by the state of the capillary and areolar circulation; and 3d, the state of the arteries.

1st. The pulse depending so much on the action of the heart, partakes of all its aberrations from the natural state, and these deviations are the consequence of idiopathic affections of the heart, or of its sympathetic disorders. The last are the most common, for the diseases of acute, and most of those of chronic irritations, extend their influence to the heart, and involve it in the morbid condition.

The modifications of the pulse arising from the contraction of the heart, are those affecting its frequency, slowness, force, and rythm or mode of pulsation.

Frequency of the pulse is the most constant and certain symptom of an existing irritation in the organs. Whenever the heart experiences irritation, either sympathetically or primitively, its contractions are quickened, and so long as a frequent pulse continues, whatever may be the improvement of other symptoms, we should always suspect a lurking inflammation, and endeavour to exterminate it.

The diminution of the frequency of the pulse, in acute diseases, is uniformly a favourable sign, while its persistence is as positive an evidence nearly of the continuance of the disease. In convalescence from gastro-enteric fevers, after the perfect reinstatement of the alimentary organs in their healthy state, I have frequently found the frequency and irritation of the pulse continue, and every attempt to increase the diet or invigorate the patient by tonics, to be attended with febrile excitement. The irritation of the heart in these cases, at first merely sympathetic, had become established permanently, and did not terminate with the cessation of the primary irritation. It is to be overcome by local depletion from the cardiac region, blisters to the same part, small bleedings, and restricted regimen. If neglected, organic disease of the heart will sometimes succeed, or the patient be cut off by dropsical effusions.

Frequency of the pulse may be combined with its force and fullness, but they do not necessarily accompany each other.

The contractions of the heart, in the majority of persons, average from sixty-five to seventy in the minute; above that number, the pulse is said to be frequent. It often mounts as high as one hundred, one hundred and twenty, and seldom beyond one hundred and fifty in the minute.

When the contractions of the heart are very feeble, from the emptiness of the vascular system, they increase in frequency, as though the deficiency in the quantity of the blood circulating, was to be compensated by the increased velocity of the circulation. It is scarcely possible to mistake the frequency of the pulse from this cause, for the frequency produced by irritation. It is always attended with extreme weakness of the pulse.

Quickness of pulse differs from frequency; it has reference to the time of each pulsation, and depends on the systole of the heart being performed with a rapid contraction. Most commonly it accompanies frequency of the pulse, and is an evidence of existing irritations. The frequent pulse of exhaustion is generally a quick pulse.

Slowness of pulse is usually employed as opposed to its frequency, and expresses the fewer number of pulsations than is usual in a given time. Rareness or paucity of pulse would be a more correct designation, to distinguish it from slowness, as contrasted with quickness. The diminution in the pulsations of the heart, manifests the absence of irritation in that organ, or its declension, if they had been previously frequent. Rareness or paucity of pulse accompanies at times a full and strong pulse, particularly in the congestions of the cerebral organs, and is also an attendant on a small and feeble pulse, especi-

ally in chronic diseases, attended with serous effusions. It is produced by digitalis, and appears to be a specific action of that remedy, diminishing the irritability of the heart, and consequently the number of its contractions.

Slowness of pulse, as opposed to its *quickness*, has relation to each pulsation. It arises from the same causes as rareness of the pulse, a state of ab-irritation or asthenia of the heart or mobile organ of the circulation, and sometimes of the softening of its parietes.

A strong or forcible pulse proceeds from the energy of the ventricular contractions. Most commonly it belongs to a fulness of the vascular system, or plethora, and manifests excitement and vigour in the heart: It attends on hypertrophy of the left ventricle.

A feeble pulse marks, in most instances, a low state of excitement in the heart; and indicates exhaustion of the vascular system. It may be accompanied with slowness or frequency. In carditis and pericarditis the pulse is said to be feeble, which then proceeds from the disability of the ventricles to contract, like other muscles, when they or their sheathes are in a state of acute inflammation.

The last modification of the pulse emanating from the heart, relates to its rythm, or mode of action. In this respect, the pulse may be equal or regular, unequal or irregular, and intermittent. In a regular or equal pulse, all the pulsations are similar; a pulse is unequal or irregular, when the pulsations do not correspond to each other in frequency, quickness, and force; a pulse is intermittent, when, after several pulsations, there occurs a momentary repose. These conditions of the pulse proceed from different modes of contraction of the ventricles. The irregular and intermittent pulses belong to organic diseases of the heart, and occur also in acute diseases, from sympathetic disturbances in that organ, which, I am disposed to believe, are only excited by irritations of the digestive organs. At least, I do not recal pulses of that character in the diseases of other organs, except of the heart itself. The irregular is a more unfavourable than the intermittent pulse. I have known instances in which an intermittent pulse was natural to the individual; it continued for years, and during the enjoyment of good health.

2d. The capillary system modifies the pulse, as to fulness or emptiness, by determining the quantity of blood contained in the vascular system, and regulates, in these respects, the state of the direct circulation. This last supplies the capillary system, which attracts from the arterial and withholds from the venous vessels the proportion of blood it requires, determined always by the state of its excitation—the vascular or direct circulation is governed, as to reple-

tion or vacuity, by the state of the capillary circulation in the different organs. Fullness or emptiness of pulse are, then, indications of the condition of the capillary circulation. These states of the pulse are produced, however, under particular circumstances, and in a manner requiring to be noticed.

When a limited extent of the capillary system is engorged with blood, as occurs in irritation and inflammation, the circulation of the congested part, is sluggish or suspended, and the portion thus affected, ceases to admit further supplies for the time, from the artery conveying the sanguine humour to it. The amount of blood which previously passed into the capillaries, is now accumulated in the artery, and passes into the veins exclusively by the direct communication, existing between those vessels. They are consequently replete with blood—the artery, completely distended, is full and hard, and it more perceptibly manifests the momentum of the heart's contractions. This I regard as the correct explanation of the full, strong pulse, felt in the arteries supplying an inflamed part, as in the radial artery, in very acute inflammation of the hand.

Inflammation of the brain or meninges with light congestion, produces the same effect in the carotid arteries; and to a greater extent, the same circumstance is observed in the extreme congestions of the brain, as in apoplexy. In these last cases, the pulse of the whole vascular system, is full, strong, and often slow. The degree and extent of the congestion, which occupies the external as well as internal capillaries of the head, arrests the capillary movements, and of course the demand of these organs receiving in a natural state, as is estimated, an eighth of the whole circulating fluid, while the general torpor of the capillary system throughout the economy, which attends on this disease, diminishes, in some degree, the call made on the circulating fluid. The vascular system, in consequence, acquires a repletion of blood, the vessels are distended, the pulse full and strong, and as no irritation exists in the heart, its contractions are slow.

Precisely the reverse is the effect on the general or vascular circulation and pulse, of irritation in the extensive membranous tissues rich in capillaries, and in capacious organs of highly vascular structure, producing in them profound congestions. The quantity of blood these organs and tissues are capable of containing, and which, under the influence of irritation they abstract and withhold from the vascular system, is so great as to reduce the general circulation to a state of extreme exhaustion. A small deficient current flows through the arteries and returns immediately by the veins. The heart in a state of asthenia, contracts with feebleness on its half-distended ca-

vities, and the pulse is scarcely to be perceived, and sometimes is entirely absent, when the volume of blood is not adequate to bring the elasticity of the arterial coats into action.

In the commencement of irritations of the internal viscera, especially of the digestive or alimentary organs, before reaction, or the irradiation of the irritation into other organs has ensued, the capillary and areolar circulation of the external surfaces is diminished, the capillary circulation concentrates towards the seat of irritation, where the blood accumulates and is detained until it is dispersed by the establishment of reaction. This concentration of the circulating or nutritive humour in a portion of the capillary system, forms the cold stage of fevers, and is the essential condition of visceral congestions, which have formed so prominent a feature of late in some systems, though their mode of production was not understood. Its direct effect is to abstract blood from the vascular system, equivalent to a depletion, and the quantity of blood of which the vessels are deprived, is proportioned to the intensity and extent of the concentric movements of the capillary circulation, and degree of congestion induced; it is often equal to the abstraction of many pounds of blood. Hence arises, in this state, the weak, feeble pulse, a sign of debility in the contractions of the heart, and emptiness of the vessels.

The same result, as to the vascular circulation and pulse, is produced by extensive irritations of the cutaneous surface, determining sanguine congestion of its capillaries. This state exists in the eruptive fevers, or exanthematæ, when of a high grade, and which are then attended with a weak, empty pulse. Scarletina, when of intense character, as in its malignant form, is a remarkable illustration of the fact. The disease, in this state, exhibits the skin from the head to the feet of a deep red, demonstrating the actual presence of red blood in the skin, in a quantity entirely unnatural. The internal mucous tissues, in this malignant form of the disease, is shown by dissection to be in the same condition. Here then is presented the ocular demonstration of the permanent congestion of the cutaneous capillaries, the detention of a large quantity of the circulating fluid in them, and its consequent deprivation from the vascular system. Now, in this form or stage of scarlatina, the pulse is always deficient in fulness and force, and in the highest grades of the disease, the pulse is reduced to such extreme exility, it is scarcely distinguishable.

This feeble, empty pulse of scarlatina maligna, has been supposed to be the consequence of extreme debility of the vital powers, and to require the sustaining energy of stimulants and tonics. I have never witnessed from their employment, more, even when lavishly admi-

nistered, than a transient effect on the circulation, and by augmenting the morbid irritation of the cutaneous and mucous surfaces, and thereby confirming their congested state, they have increased the vascular exhaustion, and have enfeebled to a greater degree, the action of the heart and pulse. Cold or tepid evaporating ablutions, used according to circumstances, by diminishing the cutaneous irritation, relax the capillary congestion, the blood resumes its natural course into the vascular system, which fills up and expands, and the pulse acquires fulness and firmness. I have seen, in scarlatina, the pulse, as ablutions were employed or discontinued, become alternately full and firm, or empty and feeble. In rubeola or measles, when malignant, and in confluent small-pox, the exhaustion of the vascular system, and extremely small and feeble pulse, are produced in this same manner.

This principle, which I consider as of the highest importance in a practical view, when fully appreciated, has a very extensive application; and it places in a very clear light, the important fact, that a patient, in irritations of great activity, is threatened at the same instant with impending dissolution, from opposite conditions of his organs—that is, from extreme feebleness and exhaustion of the vascular circulation, and violent congestive irritation in the capillaries of the cerebral, pulmonary, or abdominal viscera, suspending their functions. It exhibits also the necessity, under those circumstances, of resorting, at the same instant, to a compound and opposing treatment, explains the objects to be attained by it, and the manner in which it is to be directed.

3d. The arteries modify the pulse, when they are themselves in a pathological state, to which they are subject, as well as the other organs of the economy. Acute inflammation, as in arteritis, causes firmness in their coats, and the pulse is then hard. The inception of ossification renders the pulse obscure, and when it is complete, the artery losing its elasticity no longer responds to the shock communicated by the heart, and the pulse is lost. The coats of the arteries, in some instances, are softened from a species of infiltration of fluid into their interstices, which lessens their elasticity and impairs their power of reaction.

The calibre of the artery has an influence over the pulse. I have seen, in a case of dilatation of the heart, all the arteries preternaturally small, and which produced a remarkably small pulse. Undue enlargement of the arteries is not uncommon. The pulse, in a normal state of the circulation, is then large and full, and under excitement, is exceedingly deceptive. It appears to indicate profuse and

repeated bleedings, but fails with rapidity under sanguine depletion, assuming a peculiar yielding and flaccid sensation, as though the vessel contained a gaseous or exceedingly tenuous fluid.

The pulse in many individuals is very feeble; it is scarcely discernible. They enjoy, notwithstanding, excellent health. The energy of life does not depend on the force and velocity of the vascular or direct circulation, but on the activity of the capillary circulation. Persons who are prone to obesity, have usually a small and feeble pulse. It is a common explanation of the fact, to attribute it to compression on the arteries from the accumulation of adipose matter. This is not correct; the arteries and whole vascular system in such persons, is not developed to the same extent as in others, and the vascular circulation is more inactive.

The pulse is in some instances entirely absent, without interfering with health. This circumstance occurred in the mother of Dr. S. of this city. The pulse disappeared during an attack of acute rheumatism, which did not appear to retard her recovery, and it never returned during her subsequent life. She was active in mind and body, and possessed unusual health. In no part of the body could a pulse be detected. I attended her during a part of the time of her last illness, which was an acute inflammation of the intestines, but no pulse existed. She died while I was absent from the city, and an examination was not made to elucidate the cause of this remarkable phenomenon.

A great variety of pulses have been described by writers, who have drawn between them fine lines of discrimination, and attempted to establish a particular pulse for every disease, and for every critical symptom, the occurrence of which, it was believed, could be predicted with certainty, or whose existence could be announced merely by the pulse. By the late Professor RUSH, the pulse was regarded as a perfect nosometer, measuring with nearly absolute precision the state of the whole economy, and the grade and character of every morbid condition.

These exaggerated views of the importance of the pulse, originated before the circulation was discovered, and the production and nature of the pulse was known. They were subsequently maintained by erroneous opinions of the character of the circulation, its active forces, and the structure and office of the vessels. The direct circulation alone was understood, the capillary, and interstitial or parenchymatous were not comprehended, and the heart and large arteries were believed to be the sole causes of the circulatory phenomena. But if the doctrine of the circulation we have advocated, founded on the analysis of the organs and mechanism of this function, be adopted as

correct, it must be clear, that the pretensions claimed for the pulse, as a universal diagnostic standard, must be considerably reduced. As a positive indicator, it characterizes only the action of the heart, and the degree of repletion of the vessels. The state of the capillary circulation, and consequently of the organs of the economy generally, is not manifested directly by the pulse, which in the determination of this point, is of secondary importance. For this purpose it is to be taken in connexion with the symptoms exhibited in the disturbances of other functions, and compared with them. The heart sympathizing in most cases in the morbid affections of all the important organs, and the circulating fluid being influenced in its distribution by diseases of intensity, the pulse serves to give the value of the other symptoms, and to render their nature manifest; and it thus furnishes secondarily and by comparison, signs indicative of the condition of the capillary circulation, and the character of the pathological state of other organs than the heart.

From this examination, it then results, that the pulse is not a general nosometer, but, as a standard of disease, is principally confined to the affections, either primitive or sympathetic, of the heart, and of the direct circulation. When, as frequently occurs, the heart and the direct circulation, from a paralyzed or quiescent state of the sympathies, do not participate in the morbid disturbances of the organs, the pulse fails entirely in presenting any positive indications of the state of those organs or the nature of the affection.

The forces regulating the direct and the capillary circulation being distinct, and the offices of the two being totally different, they are often placed in a state of antagonism, and exhibit phenomena of opposing characters. The pulse in these circumstances, while it faithfully marks the precise condition of the heart's action, and the state of the circulation, would betray us into fatal errors, if it were consulted in order to determine the condition of other organs. In the congestions of the abdominal and thoracic viscera, the functions of those organs are oppressed with a load of blood, while the heart is barely kept in action from the extreme deficiency of that humour in the vascular system. In the close also of diseases of acute inflammations, widely diffused throughout the economy, important organs are pressing on to disorganization, demanding local depletion, and other sedative measures, with revulsive operations, while the action of the heart is fainting from debility, and requiring to be sustained by diffusible stimulation. These opposite indications cannot be revealed by the pulse. They are to be determined by other signs, and a reli-

ance on the pulse, in the manner that has been taught by high authorities, as a guide in estimating the condition of the economy, and in directing remedial measures, will lead to wrong conclusions, and a practice often fraught with mischief.

ART. VIII. *Observations on Hematosis, with two Cases in which this Function was imperfectly performed.* By SAMUEL JACKSON, M. D. Assistant to the Professor of the Institutes and Practice of Medicine and Clinical Practice in the University of Pennsylvania.

FROM the complicate structure, diversity of organs and functions, the number of elementary principles, and differences of active forces, existing in and composing the animal organism, any exclusive doctrine in explanation of its diseases must of necessity be replete with errors. Hence exclusive humoralism was necessarily wrong, as it neglected the solids, by which most of the vital phenomena are made manifest. Exclusive solidism is no less false, as it overlooks the fluids or humours which are organic, and are as essential to vital actions and phenomena as are the solids. While partial and exclusive views thus regulated the principles of medicine, the science was in a state of constant vacillation between the two systems mentioned above. Neither being true exclusively, and both containing many truths, neither could satisfy all minds, yet each could enlist strenuous advocates, equally convinced of the correctness of those principles they did espouse.

There is this difference, however, between the ancient doctrine of humoralism, and the modern. In the first was admitted many supposititious humours, and qualities were appropriated to them entirely hypothetical. In the modern doctrine, the humours are analyzed, and the part each plays in the organism is examined with rigorous induction. There is no other analogy between the two than the bare name.

The most important of the humours is the oxygenated, arterialized, or sanguine nutritive humour. Though apparently homogeneous, it consists of different principles, which vary in their proportions in different individuals, and in the same individual, at different periods and under different circumstances. Concerned in every vital phenomenon, the states or condition of this fluid exercise a most decided